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Considerations regarding access to gas from renewable sources to the network existing gas distribution

Considerații privind accesul gazelor din surse regenerabile la rețeaua de distribuție a gazelor naturale existentă

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Rezumat.*Consumul mondial în continuă creștere de gaze naturale și rapiditatea epuizării rezervelor de combustibili fosili au tras un semnal de alarmă specialiştilor preocupați de căutarea unor soluții energetice care să răspundă nevoilor actuale, pentru o creștere economică sustenabilă. Lucrarea de față prezintă accesul biometanului în sistemele existente de distribuție a gazelor naturale, cu scopul diminuării consumului de combustibili fosili. Acest articol investighează indicatori specifici pieței de gaze naturale din România, având drept țintă identificarea unei soluții eficiente privind suplimentarea de combustibili mai puțini nocivi decât combustibilii fosili, biometanul fiind o alternativă regenerabilă la combustibilii fosili. În acest caz, gazul „verde " - biometanul ajunge la utilizatorii finali prin intermediul conductelor de distribuție existente.*

Cuvinte cheie: gaze naturale, energie regenerabilă, biometan, sistem distribuție, sustenabilitate

Abstract. *The ever-increasing global consumption of natural gas and the rapid depletion of fossil fuel reserves have sounded the alarm to those concerned with finding energy solutions that meet current needs for sustainable economic growth. This paper presents the access of biomethane in existing natural gas distribution systems, in order to reduce the consumption of fossil fuels. This article investigates specific indicators of the Romanian natural gas market, aiming to identify an efficient solution for supplementing less harmful fuels than fossil fuels, biomethane being a renewable alternative to fossil fuels. In this case, the „green" gas - biomethane reaches the end users through the existing distribution pipes.*

Key words: natural gas, renewable energy, biomethane, distribution system, sustainability

1. Introduction

In the current environment, energy from renewable sources has been growing timidly, currently representing about 2% of total national energy production, the top ranking is still led by conventional non-renewable energy sources (coal, oil and natural gas) and non-conventional non-renewable energy sources (nuclear energy).However, with Romania's adherence to the European Green Deal (the Green Deal), the proportion of energy production from renewable sources should increase until 2030, so contributing to the creation of an energy strategy based on reducing dependence on imports, both at national and European Union level.

In order to achieve these objectives, the natural gas sector is going through a multitude of legislative changes today. Along with the other signatory states, Romania will have to create an intelligent natural gas distribution system and implement the mixture of natural gas with „green" gas in the existing pipeline system to facilitate the transition to clean energy. Other legislative objectives are found in the "Fit for 55" package: reducing energy poverty, increasing production from renewable sources and combating climate change. [1]

A development of the energy sector can only be implemented keeping in account the objectives of sustainability. To facilitate the transition to „green" energy, the International Energy Agency affirms that methane emissions coming from fossil fuels should be reduced by 45% until 2030. If this objective is achieved, global warming could be reduced by 0.3°C by 2040[2].

2. The current state regarding fossil fuels

To facilitate the application of sustainability strategies in the energy sector, the attention will focus on the process of forming the energy mix to reduce the use of fossil fuels. The way in which we can contribute is through the procedure of injecting renewable gases into the distribution networks.

Regarding to the identification of the way in which we can implement the objectives of sustainability to reduce the consumption of fossil fuels, firstly the composition of natural gases will be presented, then the procedure for determining the amount of energy consumed.

Since natural gas is part of the category of fossil fuels, the development of the energy sector is done by protecting the environment, using other types of sources, among which renewable sources are considered. [3]

Examining the composition of natural gases (Table 1), methane (CH_4) is identified as the principal component, to which is added the mixture of heavy hydrocarbons (butane, ethane, propane, carbon dioxide, nitrogen, hexane plus and pentane). Along with these, minor components are recorded in the chemical composition of natural gases: carbon monoxide (CO), nitrogen (N_2), hydrogen (H_2), oxygen (O_2), helium (He) as well as traces of constituents originating from sulfur. [4]

Table 1

Minimum quality requirements necessary for the transport of natural gas and biomethane through pipelines related to the molar concentration, denoted wich Ci; Principal constituents for natural gas, raw biogas and upgraded biogas (biomethane)

Minor and major percentage components					
Natural gases	Ci	Raw biogas	C_i	Enhanced biogas (biomethane)	C_i
methane (CH_4)	min. 85	methane (CH_4)	45-75	methane (CH_4)	min. 90
carbon dioxide (CO_2)	max. 8	carbon dioxide (CO_2)	30-40		
ethane (C_2H_6)	max. 10	oxygen (O_2)	max. 1		
butane (C_4H_{10})	max. 1,5	hydrogen sulphide (H_2S)	0,0025-0,0030 (25-30 ppm)		
propane (C_3H_8)	max. 3,5	ammonia (NH_3)	max. 0,01 (max. 25-30 ppm)		
azote (N)	max. 10	azote (N)	1-2		
pentane (C_5H_{12})	max. 0,5	siloxane (R_2SiO)	traces		
hexane (C_6H_{14})	max. 0,1	water (H_2O)	traces		

Methane is one of the component elements in the gas mixture which helps to form the burning process. Along with it, alkanes and inert gases are identified in the natural gas structure, which are transported in the distribution network in lower concentrations.

Following the burning process, heat is released through rapid oxidation of combustible substances. Reaction products are used to make the burning process happen, and combustion gases are produced when the fuels are burnt.

Through the process of determining the amount of energy consumed by the final user, it is possible to determine the contribution of each participant to the consumption of natural gas.

The calculation formula for determining the amount of energy consumed by final users when using equipment consuming gaseous combustibles is as follows[5]:

$$E = V_b \text{ x } PCS \quad (1)$$

In which: E - natural gas energy (kWh), effect of converting the amount of natural gas into energy units; V_b - the corrected volume, determined under reference conditions (m^3); PCS- the superior calorific value of natural gas (kWh/mc), determined at the combustion temperature of 15^0C, using chromatographs.

In order to determine the amount of energy consumed, the superior calorific power must be known (Table 2). The superior calorific power, also known as the heat of burning, is established by economic operators [6] and is a qualitative parameter, registering inflections depending on the place of origin (domestic production, import).

Table 2

Superior calorific value for different types of gas

Energy values - natural gas, methane, biogas and biomethane				
Nr. Crt.	Name	Gaseous fuel type	Unit	Value
1	Superior calorific power (PCS)	natural gas	kWh/mc	10,46
2	Superior calorific power (PCS)	methane	kWh/mc	11,06
3	Superior calorific power (PCS)	biogas	kWh/mc	4,44-7,78
4	Superior calorific power (PCS)	biomethane	kWh/mc	6,75-9,41

From a theoretical point of view, calorific power (kJ/ m^3N) for gaseous fuels it is expressed as follows [13]:

$$PC=\sum_{i=0}^{n}\frac{P_i \cdot c_i}{100} \quad (2)$$

where:

P_i- the specific calorific value of the element i (kJ/m^3N); C_i- concentration of composition I (expressed as a percentage).

So, on the basis of a chromatographic analysis, it is possible to determine the superior calorific power calculated from the complete burning of one m^3 of combustible.

Starting from the latest national monitoring reports for the internal natural gas market [7] and calculating for the year 2021 the annual consumption of the final domestic user in Romania, the value of 20.34 kWh/user in 2021 resulted. Calculated for Europe, energy consumption from fossil fuels is 35.11 kWh/user in 2021 [8]. It is noted that Romania is below the average threshold of energy consumption from fossil fuels.

3. Fuel gas - compatibilities

A way in which we can participate in the EU's common action on harnessing renewable gas is to inject it into existing pipelines. Thus, it is necessary to establish the compatibility conditions between these types of gases and the non-renewable ones. It should be emphasized that there is a European Standard in the works that tries to constitute a common norm regarding the technical conditions that must be respected for the contribution to the energy mix of biomethane [9]. Among the technical conditions that will be agreed by the signatory states (currently 17) are, among others: the determination of the Wobbe index and the calorific power, conditions that differ according to each country.

Both Romania and the rest of the EU member states have identified a way to combat the current energy crisis, having to establish certain common quality criteria that define gases.

Researching the national energy sector, we found that there is potential to supplement a certain amount of biomethane, derived from biogas, in natural gas distribution pipelines.

Biogas is obtained through biotechnological operations, involving the process of anaerobic fermentation made from the degradation of organic matter. Through the technological process of biogas treatment, biomethane is obtained, which is part of the category of renewable gases.

A characteristic that needs to be highlighted is the difference between biogas and natural gas in terms of chemical compositions (Table 1). The main component of the gas mixture is methane, which contributes rapidly to the increase in greenhouse gas emissions, in contrast to biomethane, which can be obtained through sustainable methods. Along with it, among the chemical compounds we also list: carbon dioxide (CO_2), hydrogen (H_2), but they can also include certain impurities [10]. By means of the innovative techniques used to eliminate the harmful constituents that are part of the biogas composition (H_2S, CO_2, siloxanes), the following are listed: the absorption process, which includes chemical or physical absorption; the adsorption process (adsorption by pressure and temperature variation), the vacuum technique, the membrane separation method, the cryogenic separation method, the carbon capture and storage method and the use of hybrid technologies [11].

From the point view of compatibility conditions for the existing natural gas network, biogas is a key element to reduce dependence on imports. However, in this case, through the biogas purification process, the aim is to eliminate the existing CO_2 content of 30-40% and remove other contaminants such as: water vapor, hydrogen sulphide (H_2S), oxygen (O_2), nitrogen (N), ammonia (NH_3), siloxane (R_2SiO) and dust particles, with the aim of obtaining biomethane, which has qualities similar to natural gas. Biogas contains between 45-75% methane (CH_4), and to improve energy efficiency, the methane content will be increased by reaching the minimum quality threshold (Table 1) [11].

In the context of harmonizing national legislation with regulations issued at the EU level, it is necessary to establish the Wobbe index, to determine the reference threshold for the superior calorific power, establish the temperature by reference to standard reference conditions. All this is necessary to achieve compatibility between the two types of combustible gases used [10].

The Wobbe index (expressed in MJ/m^3) is defined as follows [13]:

$$I_w = \frac{PCS}{\sqrt{G_S}}, \quad (3)$$

where:

PCS –superior calorific power, expressed in MJ/m^3; G_s – specific gravity, expressed in N/m^3.

The Wobbe index represents one of the technical indicators characteristic of fuel gases, being defined as an indicator for their interchangeability. Fig. 1 inserts the recommended energy values for the Wobbe index specific to natural gas and methane compared to biomethane. Thus, the recommendations for harmonizing the legislation on unitary standardization, with the implications of the signatory member states, regarding biomethane for injection into natural gas distribution pipelines were taken into account [13].

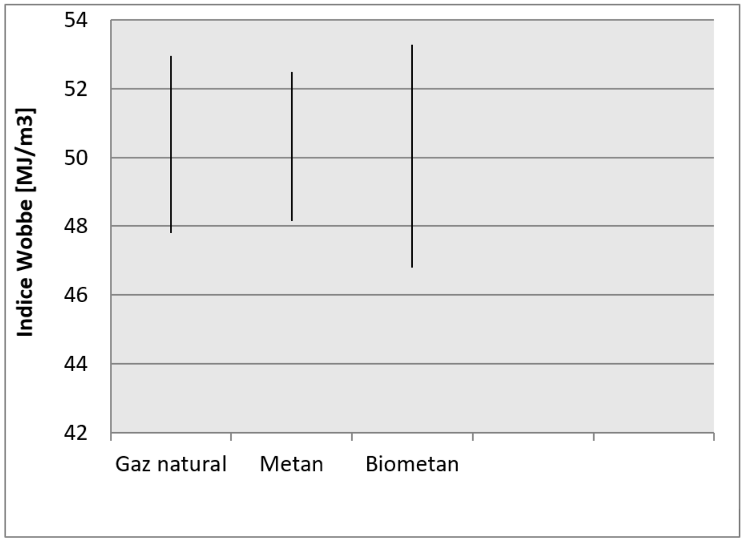

Fig. 1. Representative Wobbe index for natural gas, biomethane and methane

Due to the high concentration of CO_2 existing in the raw biogas, the calorific power is implicitly influenced. The biogas treatment process aims to capture and store the CO_2 content (as well as other contaminants) in order to obtain biomethane that will acquire superior characteristics.

Combustible gases obtained through biological processes have a low calorific power, approximately 4.44-7.78 kWh/mc, but following the elimination of the CO_2 concentration, as well as the removal of other specified contaminants listed, an increase in the methane content will be recorded above 90 %. It is known that the PCS for biogas is between 4.44-7.78 kWh/mc, respectively 45-75% methane. The PCS for biomethane is calculated, considering that the improved biogas contains 98% methane, then the PCS of biomethane will be between 6.75-9.41 kWh/mc, the PCS being influenced by the raw material used.

4. Conclusions

In the present article we have created an overview for the possibility of introducing biomethane into the existing natural gas networks. There is a need to ensure a source of renewable fuel energy to complement the natural gas in the distribution system, namely biomethane.

Romania's economy could have problems if only fossil fuels were consumed. The consumption can be covered by supplementing with biomethane in the existing natural gas distribution networks, taking into account the Wobbe index that must be respected, appreciating that the necessary biomethane could be obtained from the recovery of organic waste.

Naturally, the demand for natural gas will increase, the competition on the gas market will also increase. Existing networks will be extended and interconnected with those of EU member states, having a positive influence on improving energy security. Romania must target for a technological development aimed at the use of „green" gases, in order to reduce the consumption of fossil fuels.

Some different approaches to the EU regulations for creating an intelligent natural gas distribution system that include „green" gases persist today, not being applicable in Romanian legislation. The verification of the specialized literature shows the need to establish the influential key index for determining the compatibility of the two types of fuel gas as a basis for the development of the future method by injecting biomethane into the existing systems, thus reducing the consumption of natural gas. The overall conclusion is that the influential indicator chosen for gas interchangeability highlighted in this paper helps research and development of mixed gas systems, determining consumption analysis methods and reducing fossil fuels used. This response to current needs ensures sustainable economic growth for all natural gas consumers.

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